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MASSACHUSETTS

INSTITUTE OF TECHNOLOGY,

BOSTON, MASS.

DEPARTMENT
OF
MECHANICAL ENGINEERING.

BOSTON:
BEACON PRESS: THOMAS TODD, PRINTER,
1892.

OFFICERS OF INSTRUCTION

In Mechanical Engineering.

Gaetano Lanza, C.E., Professor of Theoretical and Applied Mechanics; in charge of the Department of Mechanical Engineering.

Peter Schwamb, S.B., Associate Professor of Mechanism and Director of the Workshops.

Cecil H. Peabody, S.B., Associate Professor of Steam Engineering.

Dwight Porter, Ph.B., Associate Professor of Hydraulic Engineering.

Jerome Sondericker, C.E., Assistant Professor of Applied Mechanics.

Allyne L. Merrill, S.B., Assistant Professor of Mechanism.

Edward F. Miller, S.B., Assistant Professor of Steam Engineering.

Bertrand R. T. Collins, S.B., Instructor.

Edward V. French, S.B., Instructor.

George W. Hamblet, S.B., Instructor.

Arthur W. Williston, S.B., Instructor.

John O. DeWolf, S.B., Assistant.

Howard C. Slater, S.B., Assistant.

Fred. A. Cole, S.B., Assistant.

Carleton A. Read, S.B., Assistant.

James Swan, S.B., Assistant.

Clifford M. Tyler, S.B., Assistant.

Charles P. Wetherbee, S.B., Assistant.

OFFICERS OF INSTRUCTION

IN OTHER RELATED DEPARTMENTS.

JOHN D. RUNKLE, Ph.D., LL.D., Walker Professor of Mathematics.

GEORGE A. OSBORNE, S.B., Professor of Mathematics.

CHARLES R. CROSS, S.B., Thayer Professor of Physics and Director of the Rogers Laboratory.

SILAS W. HOLMAN, S.B., Associate Professor of Physics.

WEBSTER WELLS, S.B., Associate Professor of Mathematics.

LINUS FAUNCE, S.B., Assistant Professor of Drawing.

S. HOMER WOODBRIDGE, A.M., Instructor of Heating and Ventilation.

AUGUSTUS H. GILL, Ph.D., Instructor in Gas Analysis.

THEODORE B. MERRICK, Instructor in Woodwork and Foundry-work.

JAMES R. LAMBIRTH, Instructor in Forging.

ADMINISTRATIVE OFFICERS OF THE INSTITUTE.

President	FRANCIS A. WALKER.
Secretary	H. W. TYLER.
Bursar	ALBERT M. KNIGHT.

SCHEDULE OF THE COURSE IN

MECHANICAL ENGINEERNIG.

FIRST YEAR.

FIRST TERM.	SECOND TERM.
Solid Geometry.	Plane and Spherical Trigonometry.
Algebra.	General Chemistry.
General Chemistry.	Chemical Laboratory.
Chemical Laboratory.	Political History since 1815.
Rhetoric and English Composition.	French (or German).
French (or German).	Mechanical Drawing and Descriptive Geometry.
Mechanical Drawing.	Freehand Drawing.
Freehand Drawing.	Military Drill.
Military Drill.	

SECOND YEAR.

FIRST TERM.	SECOND TERM.
Principles of Mechanism.	Mechanism: Cotton Machinery; Machine Tools; Gear teeth.
Drawing.	Drawing.
Carpentry and Wood turning.	Pattern Work.
Analytic Geometry.	Differential Calculus.
Descriptive Geometry.	Physics.
Physics.	English Literature and Composition.
English Literature.	German.
American History.	
German.	

THIRD YEAR.

FIRST TERM.	SECOND TERM.
Steam Engineering; Valve Gears: Thermodynamics.	Steam Engineering; Boilers.
Drawing.	Drawing, Design and Use of Surveying Instruments.
Forging.	Engineering Laboratory.
Integral Calculus.	Forging; Chipping and Filing.
General Statics.	Strength of Materials; Kinematics and Dynamics.
Physics: Heat.	Physical Laboratory.
Physical Laboratory.	English Composition.
German.	German.

FOURTH YEAR.

FIRST TERM.	SECOND TERM.
Steam Engineering.	Hydraulic Motors.*
Hydraulics.	Engineering Laboratory.
Dynamics of Machines.	Machine Tool Work.*
Machine Design.*	Strength and Stability of Structures; Theory of Elasticity.
Engineering Laboratory.	English Composition.
Clipping and Filing; Machine-Tool Work.*	Thesis.
Strength of Materials; Friction.	
Metallurgy of Iron.	
Heating and Ventilation.*	
Elements of Dynamo Machinery.	
Options.	*Options.*
1. Marine Engineering.	1. Marine Engineering.
2. Locomotive Construction.	2. Locomotive Construction.
3. Mill Engineering.	3. Mill Engineering.
4. Naval Architecture and Marine Engineering.	4. Naval Architecture and Marine Engineering.

* Not taken in Option 4.

In view of recent developments of great importance in the Mechanical Engineering Department of the Institute since the issue of the last special circular in 1883, it seems advisable to publish a separate and detailed account of the present condition and work of the department. Regular students at the Institute will hereafter be expected to choose their professional courses at the close of their first term. In considering the propriety of undertaking the course in Mechanical Engineering it should be borne in mind that of the subjects studied in the first and second years those most vital to success are Mathematics, Physics and Drawing (including Descriptive Geometry). All the later professional work of the department is so completely dependent upon these branches that no student can expect to succeed in it without having mastered them. However much interest he may have in machinery in motion, when he attempts serious engineering work he must have a firm grasp of these fundamental subjects.

The professional work of the course in Mechanical Engineering may be classified as follows:

(*a*) Mathematics, Physics and Applied Mechanics, given outside the department, the last including the study of and practice in testing the strength of materials.

(*b*) Class-room work of the department proper.

(*c*) Drawing.

(*d*) Engineering laboratory work.

(*e*) Shopwork.

(*f*) Visits to engineering works and manufacturing establishments.

Passing over the first year, in which the work of the different courses is mainly introductory and not greatly differentiated, the course is organized as follows:

In the second year the more essential subjects given outside the department are Analytic Geometry, Differential Calculus and Physics. The department gives a course in the principles of mechanism, and in the construction of gear teeth, followed by courses on the mechanism of machine tools and of cotton machinery. In intimate connection with this, practice is given in making working drawings of parts of machinery from measurements, and other drawings illustrating the class room work. Instruction is also given in carpentry and pattern making at the shops.

The more important third-year subjects are:

(*a*) Integral Calculus.

(*b*) Physics, including a special study of Heat and work in the physical laboratory.

(*c*) Applied Mechanics, devoted mainly to a mathematical study of the strength of materials.

(*d*) Valve gears.

(*e*) Thermodynamics and Steam Engineering. This course includes a detailed study of the principles of Thermodynamics, mathematically treated; a discussion of the properties of gases and vapors, especially steam; of the flow of steam and other fluids, of the steam injector and of the hot-air engine. All of these topics are treated in such a way as to give the student a good foundation in the principles of Thermodynamics, especially as they apply to the steam engine. This is followed by a study of the steam engine itself, of the compound and multiple-expansion engine and of the mode of testing steam engines, the remainder of the course being devoted to a study of steam boilers.

(*f*) Drawing. The course for the first term includes detail drawings, from measurement, of some machine, and assembly drawings made from these detail drawings. In the second term it is devoted to boiler drawing and the working out of valve gears and mechanism designs.

(*g*) Engineering Laboratory Work. This is given during the second term, and is devoted to drill in steam engine tests, for which the 9-inch, 16-inch and 24-inch by 30-inch Allis triple-expansion engine, and also the 8-inch by 24-inch Harris-Corliss engine, are used. In these engine tests the water consumption is determined by condensing and weighing the steam after it has passed through the engine.

(*h*) Shopwork. The shopwork of the third year includes forging and a portion of the chipping and filing.

FOURTH YEAR.

The work of the first three years, as above described, is taken by all students in the course in Mechanical Engineering. In the fourth year four options are offered, of which one is required.

These options are:

Locomotive Construction.
Marine Engineering.
Mill Engineering.
Naval Architecture.

The following fourth-year subjects are pursued by all students who take any of the first three options:

(*a*) Applied Mechanics. The earlier work in this subject aims to familiarize the students with such data on the strength of materials used in construction as have been obtained by means of experiments, especially those made on a practical scale, in different parts of the world. Pains are taken to keep this work well up to date. This is followed by a study of friction and lubrication, of continuous girders, of stone and iron arches and of the theory of elasticity. Besides the above, each student has made during the present school year (1891–92) the following tests in the laboratory:

1. A test to determine the modulus of elasticity, the limit of elasticity and tensile strength of a cast iron or wrought iron, or steel rod or bar, or the transverse strength of a coupling.
2. A test of the deflections, and of the transverse strength of a full-size iron or steel I-beam, or of a wooden beam subjected to a transverse load.
3. A test to determine the modulus of elasticity, and the tensile strength of annealed or bright iron wire.
4. A test to determine the shearing modulus of elasticity of a shaft.
5. Tests of the tensile strength of hydraulic cement.
6. Tests of the compressive strength of hydraulic cement.

(*b*) Steam Engineering. A careful study is made of such data as have been based on reliable tests made on large single, compound and multiple-expansion engines in different parts of the world. The gas engine is studied, also air compressors and refrigerating machines.

(*c*) Machine Design. To this work are devoted eight hours per week during the first half year. Each student is required to make a certain number of designs ; as the design of a boiler, of a large shaft with gears and pulleys, of a set of hangers, etc. ; and for each design he is required to make all the calculations and drawings necessary for every detail, determining the strength of every part by means of the principles already learned, and not by means of calculations made according to some empirical formula. The scope of the designs assigned is sufficiently limited to enable the student to work out every detail, and then to apply what he has already learned, as it is believed that only by such thorough work can real benefit be obtained.

(*d*) Hydraulics and Hydraulic Motors. The main principles of hydraulics are taught, including the flow of water through orifices and pipes and over weirs. Hydraulic motors are studied with particular attention to the turbine.

(*e*) Industrial Management. Lectures have been given during the present school year (1891–92), and this work is to be gradually extended until a course is developed of such length and thoroughness as the importance of the subject demands. This involves a study of the organization and relations of the various departments of an industrial establishment both in the office and in the workshop, the conduct of accounts, the methods of compensating labor and of superintendence and the effect upon cost of production of interest and other forms of expense.

(*f*) Engineering Laboratory Work. This can be best illustrated by a list of the tests made during the past year (1891–92) by each student. It is as follows, viz. :

Test of the transmission of power by belting.
Test of the performance of a surface condenser.
Test of a direct acting steam pump.

Test of the flow of steam.
Valve setting (plain slide valve).
Test of a pulsometer.
Test of a centrifugal pump.
Calibration of orifices for the flow of water.
Determination of the clearance of an engine.
Use of the Webber dynamometer.
Use of the Emerson power scale.
Valve setting (double valve).
Testing gauges by means of the mercury column.
Test of a 208 H. P. boiler, the test continuing for 128 hours, each man working eight hours.
Test of the steam injector.
Use of three different kinds of calorimeters.
Test of a Swain turbine.
Test of a rotary pump.
Measurement of the flow of water by means of orifices and weirs.
Test of a water motor.
Test of an Ericsson hot-air engine.
Valve setting (Harris-Corliss engine).
Analysis of chimney gas.
Test of a battery of boilers of 416 H. P., the test lasting 56 hours, each student working eight hours.
Application of Hirn's analysis to the triple-expansion engine in the laboratory.

In addition to the above some performed the following, viz.: a test of the efficiency of a Weston differential pulley block; a test of the efficiency of jackscrews.

Each test is performed by a squad of from two to five students, and then the results are worked up and handed in within two or three days by each member of the squad.

(*g*) Heating and Ventilation (a short course).
(*h*) Metallurgy (a short course).
(*k*) Dynamo-electrical Machinery (a short course).
(*l*) Shopwork, including machine tool work and that portion of chipping and filing not completed in the third year.
(*m*) The option.
(*n*) The thesis.

The above represents the work done by all students taking the first three options. In the fourth option students take the work in Marine Engineering; but replace Machine Design, Shopwork, Hydraulic Motors, and Heating and Ventilation by the study of Naval Architecture.

There remains now to speak more in detail of
The work done in the several options.
The thesis work.
The equipment of the engineering laboratory and of the workshops.

THE OPTIONS.

The Option in Locomotive Construction. This course begins with a careful study of the form and proportions of the details of the more usual types of locomotives, and of the strength of some of the more important parts. Subsequently, the following subjects are discussed, viz.: train resistance; brakes; heating cars by steam from the locomotive; compound locomotives; the economy and performance both of simple and of compound locomotives as shown by tests.

The Option in Marine Engineering. This includes a detailed study of the design and construction of single, compound and multiple-expansion marine engines, with a discussion of their form, proportions and efficiency, as well as the strength of the several parts.

The Option in Mill Engineering. Mill construction is studied together with the processes to be carried out in a cotton mill, this study of processes being carried far enough to enable the student to take up intelligently the laying out of machinery to best advantage, including the planning of the power plant and the distribution of the power, all leading up to the designing and building of the mill itself; methods of rope transmission are also examined.

The Option in Naval Architecture. To this subject are devoted 225 hours during the first half, and 180 hours during the second half year. An extended course, with proper drawings and calculations, is offered in the Theory of Naval

Architecture, similar to that given in the government schools of England and France. The department is now in possession of drawings, lines of ships, displacement sheets and other material necessary for carrying on the work.

THESIS.

The thesis required of every candidate for graduation involves the investigation of an assigned problem. In connection with the thesis a large amount of investigation is carried on under the direction of some one of the instructing staff. Many of the results are published from time to time in engineering periodicals ; and it is largely by means of this work that the department is enabled to carry on a large amount of original investigation (mostly experimental) in mechanical engineering subjects.

TITLES OF THESES OF THE CLASS OF 1891.

A Test of a Mt. Washington Locomotive.
An Experimental Study of the Deflection of Parallel-Rods transmitting Power.
An Investigation of the Action of the Reciprocating Parts in certain Marine Engines.
Tests upon a " Linde " Refrigerating Plant.
Tests on a " Sturtevant Steam Hot Blast Apparatus."
Experiments to determine the Amount of Moisture that Steam will carry.
Comparative Tests upon the Strength of Unbleached and Bleached Cotton Cloth.
An Experimental Investigation in regard to the Stresses and Strains in Iron and Steel I-Beams.
An Experimental Study of a Method of determining the Vertical Throw in the Drivers of a Locomotive.
An Experimental Study of the Action of the Flat-nose Diamond-point Lathe Tool.
Experiments on the Friction of Bolt Threads.
The Explosion of Gases in a Closed Vessel.
Investigation upon Torsion Dynamometers.

Study of the Action of the Steam Injector.
Experiment on the Value of the Steam Jacket on a Direct-acting Pumping Engine.
Some Tests on Elevators.

THE ENGINEERING LABORATORIES.

The objects to be accomplished by these laboratories are the following: First, to give the students practice in such experimental work as engineers in the pursuit of their profession are called upon to perform; second, to afford some experience in carrying on original investigations in engineering with such care and accuracy as to render the results of real value to the professional community; third, by publishing, from time to time, the results of such investigations, to add gradually to the common stock of knowledge. These laboratories are situated in the engineering building, where they occupy the two lower floors, 50 x 150 feet each. The laboratory for testing the strength of materials is furnished with the following apparatus: An Olsen testing machine of fifty thousand pounds capacity, for determining tensile strength, elasticity and compressive strength; a testing machine, of the same capacity, for determining the transverse strength and stiffness of beams up to twenty-five feet in length, and of framing-joints used in practice; machinery for the measurement of the strength and twist of shafting; for testing the tensile strength of mortars and cements; for testing the strength of ropes; for testing the effect of repeated stresses upon the elasticity and strength of iron and steel; for determining the strength and elasticity of wire; for determining the deflection of parallel rods when running under different conditions; also accessory apparatus for measuring stretch, deflection and twist. Besides the above stated apparatus, a horizontal Emery testing machine of 300,000 pounds capacity is now (May, 1892) being constructed for this laboratory by William Sellers & Co., of Philadelphia. It will contain all the essential features of the 800,000 pounds testing machine at the Watertown arsenal, built by Albert H. Emery. The new machine will be suitable for testing a compression specimen eighteen feet long and a tension specimen twelve feet long, and will enable the department of Applied Mechanics to undertake and carry out a kind and amount of experimental investigation not otherwise possible, and to obtain a large number of results of value in practical engineering work, such as could not be obtained by means of machines of smaller capacity.

The hydraulic laboratory contains (1) a closed tank five feet in diameter and twenty-seven feet high, connected with a standpipe ten inches in diameter and about ninety feet high ; (2) apparatus, in connection with the tank and standpipe, for making experiments on the flow of water through orifices and mouthpieces, over weirs and in pipes, under different heads and conditions, and on the losses of head occurring under different circumstances ; (3) a six-inch Swain turbine so arranged that it can be run under different heads, and that measurements can be made of the power exerted, of the efficiency, etc., under different gates ; (4) a Pelton water motor arranged for similar experimental work ; (5) a cylindrical steel measuring tank of 280 cubic feet capacity ; (6) main lines of three-inch brass pipes, fitted with orifices, branches, diaphragms, nozzles, etc. ; and (7) apparatus for exact determination of the velocity and cross section of jets of water.

The steam laboratory contains a triple-expansion engine, with cylinders 9 inches, 16 inches and 24 inches in diameter respectively, and of 30-inch stroke, arranged in such a way as to be run single, compound or triple, as desired for the purposes of experiment. This engine is of the Corliss type, and was built by E. P. Allis & Co. It has a capacity of about 150 horse power when running triple, with an initial pressure of 150 lbs. in the high-pressure cylinder. It is connected with a surface condenser and other apparatus necessary to adapt it to the purposes of accurate experiment.

This laboratory also contains a 16 horse-power Harris-Corliss engine and an 8 horse-power engine used for giving instruction in valve setting, etc. It is equipped with several surface condensers, steam pumps, calorimeters, mercurial pressure and vacuum columns; apparatus for determining the quantity of steam issuing from a given orifice or through a short tube under a given difference of pressure; apparatus for testing injectors; and with indicators, planimeters, gauges, thermometers, anemometers and other accessory apparatus. The engineering laboratories are provided with a number of friction brakes; with machinery for determining the tension required in a belt or rope to enable it to carry a given power, at a given speed, with no more than a given amount of slip; with five transmission dynamometers; with a complete set of Westinghouse air-brake apparatus, including the parts belonging to the car and to the locomotive; with the pump and engineer's valve of the New York air brake; with an 8-inch, a 12-inch and a 48-inch weir for measuring water, also an orifice for the same purpose; with a locomotive link model; with a centrifugal pump and a rotary pump; with a hot-air engine; with a pulsometer; and with cotton machinery as follows: two cards, a drawing frame, a speeder, a fly frame, a ring frame and a mule, as well as accessory apparatus. There are also available, for the purposes of experiment in connection with the work of these laboratories, a horizontal tubular boiler and two large Babcock & Wilcox boilers, situated in the Rogers Building. There are also a boiler, a 40 horse-power Brown engine, a number of looms and other apparatus in the workshops.

WORKSHOPS.

The workshops are further equipped as follows:

The carpentry, wood-turning and pattern-making departments contain 40 carpenter's benches, 2 circular-saw benches, a swing saw, 2 jig saws, a buzz planer, a mortising

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machine, 36 wood lathes, a large pattern maker's lathe and 36 pattern maker's benches. The foundry contains a cupola furnace for melting iron, 2 brass furnaces, a core oven and 32 molder's benches. The forge shop contains 32 forges, 7 blacksmith's vises and 1 blacksmith's hand drill. The machine shop contains 23 engine lathes and 17 hand lathes of recent approved patterns, 2 machine drills, 3 planers, a shaping machine, a universal milling machine, a universal grinding machine and 32 vise benches arranged for instruction in vise work.